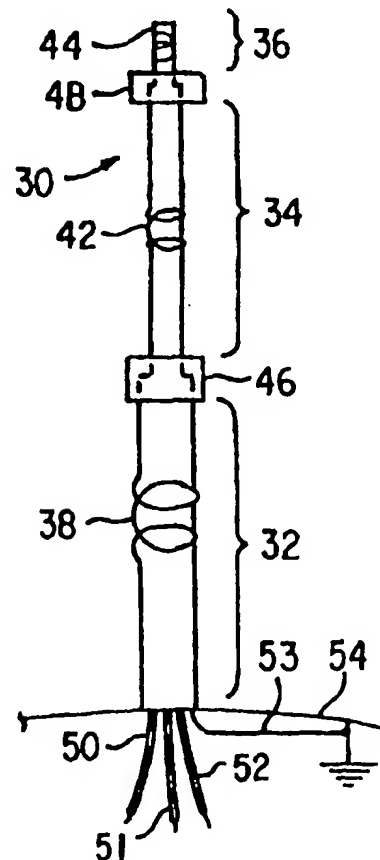




## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<b>(51) International Patent Classification <sup>6</sup>:</b> <b>H01Q 1/32, 9/04</b>	<b>A1</b>	<b>(11) International Publication Number:</b> <b>WO 97/15961</b> <b>(43) International Publication Date:</b> 1 May 1997 (01.05.97)
<b>(21) International Application Number:</b> PCT/US96/17046 <b>(22) International Filing Date:</b> 25 October 1996 (25.10.96)  <b>(30) Priority Data:</b> 08/549,099 27 October 1995 (27.10.95) US  <b>(71) Applicant:</b> GEOTEK COMMUNICATIONS, INC. [US/US]; 20 Craig Road, Montvale, NJ 07645 (US).  <b>(72) Inventor:</b> HILSEN RATH, Oliver, A.; Round Hill Country Club, 32 Essex Court, Alamo, CA 94507 (US).  <b>(74) Agent:</b> NELSON, Jeffry, H.; Nixon & Vanderhye P.C., 8th floor, 1100 North Glebe Road, Arlington, VA 22201-4714 (US).		<b>(81) Designated States:</b> AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, UZ, VN, ARIPO patent (KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).  <b>Published</b> <i>With international search report.</i>
<b>(54) Title:</b> A LINEAR DIVERSITY ANTENNA  <b>(57) Abstract</b> <p>An antenna (30) for a vehicular radio terminal is disclosed. The antenna (30) includes two sections (32, 34) which are vertically oriented in a linear fashion. A third antenna section (36) can be added. The first antenna section (32) is adapted to be supported on the vehicle. An insulator (46) is added between the antenna sections (32, 34) to provide electrical insulation between the sections (32, 34). The multiple antenna sections can be used to provide reception of multiple communication signals or to provide diversity reception.</p>		



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## A LINEAR DIVERSITY ANTENNA

### Background of the Invention

5 The present invention relates to communication systems. More particularly, it relates to antenna apparatus for receiving signals in communication systems.

Communication signals that are transmitted over communication systems are subject to many degradations. For example, one common problem communication systems face is fading, wherein the received signal strength falls below an acceptable threshold and the  
10 communication signal cannot be properly processed. There are other problems familiar to those skilled in the art.

One way of overcoming these problems and improving reception of communication signals is to utilize diversity reception wherein at least two spatially separated antennas are used to receive a transmitted  
15 communication signal. Then, the received signals can be processed. By selecting the received signal with the best characteristics, reception is improved. One drawback to the diversity technique is the need for multiple antennas. This drawback is particularly severe in the mobile communication environment, where multiple holes must be cut in  
20 vehicles to support the multiple antennas.

To overcome these and other limitations, new diversity reception apparatus is needed.

### Summary of the Invention

The present invention provides an antenna useful in receiving  
25 diversity signals. The antenna includes a first antenna section having two ends. The first end is adapted to be supported on a vehicle with a vertical orientation. The antenna also includes a second section having two ends, the first end being connected to the second end of the first antenna section such that the second antenna section is vertically  
30 oriented on top of the first antenna section. It is preferred to provide an insulator for electrically isolating the first antenna section from the

second antenna section is placed between the two antenna sections.

Several means of connecting the antenna sections to processing components are contemplated. In a first embodiment, four wires are used. A first wire is connected to the ground of the first antenna section, a second wire is connected to the ground of the second antenna section, a third wire is connected to the output of the first antenna section and a fourth wire connected to the output of the second antenna section. In another embodiment, only three wires are used. In this embodiment, a first wire is connected to the ground of the first antenna section and to the ground of the second antenna section, a second wire is connected to the output of the first antenna section and a third wire is connected to the output of the second antenna section.

The invention will now be described in connection with certain illustrated embodiments, however, it should be clear to those skilled in the art that various modifications, additions and subtractions can be made without departing from the spirit and scope of the claims.

#### Description of the Drawings

FIG. 1 illustrates a first embodiment of the linear diversity antenna of the present invention;

FIG. 2 illustrates a second embodiment of the linear diversity antenna of the present invention;

FIG. 3 illustrates an electrical diagram in accordance with a preferred embodiment of the present invention; and

FIG. 4 illustrates the antenna structure of the present invention mounted to a vehicle.

#### Description of the Preferred Embodiment

FIG. 1 illustrates an antenna structure 10 having two sections 12 and 14. The first antenna section 12 includes an inductive element 16 as well as a first end 17A and a second end 17B. The first end 17A is adapted to be connected and supported on a vehicle such that the

antenna section 12 is vertically oriented. Apparatus and method to connect antennas to vehicles are well known.

5 The second antenna section 14 also has an inductive element 20 as well as a first end 21A and a second end 21B. The first end 21A is connected to the second end 17B of the first antenna section 12 such that the second antenna section 14 is vertically oriented on top of the first antenna section 12. Thus, the antenna sections 12 and 14 are oriented so that the antenna structure 10 is linear.

10 In accordance with the present invention, an insulator 24 is optionally placed between the first antenna section 12 and the second antenna section 14. The insulator 24 electrically isolates the first antenna section 12 from the second antenna section 14. The insulator 24 may be constructed from any non-conductive material.

15 The antenna structure 10 has four wires 25, 26, 27 and 28 that preferably exit from the bottom of the antenna structure 10. The wires 26 and 28 are preferably connected to the ground of the first antenna section 12 and the second antenna section 14, respectively. When the antenna 10 is connected to a vehicle, the ground wires 26 and 28 are also preferably connected to vehicular ground 29.

20 The wire 25 is connected to the active element of the first antenna section 12 to provide the signals received by the first antenna section 12 to processing circuitry. The wire 27 is connected to the active element of the second antenna section 14 to provide the signals received by the second section 14 to processing circuitry.

25 In an alternate embodiment, the antenna structure 10 only has three wires exiting the bottom of the structure 10. In this embodiment, the wires 25 and 27 are again connected to the active elements of the first 12 and second 14 antenna sections, respectively, to provide the received signals to processing circuitry. The wire 28, however, is not  
30 used. Instead, the wire 26 is connected to the ground of the first and

second antenna sections 12 and 14.

Referring to FIG. 2, an alternate embodiment of the present invention is illustrated. The antenna structure 30 of FIG. 2 includes a first antenna section 32, a second antenna section 34 and a third antenna section 36. Each of the antenna sections 32, 34 and 36 has an active element 38, 42 and 44, respectively. As before, insulator elements 46 and 48 are preferably provided between the first 32 and second 34 antenna sections and between the second 34 and third 36 antenna sections, respectively, in order to electrically isolated the antenna sections 32, 34 and 36.

In FIG. 2, four wires 50 to 53 exit the bottom of the antenna structure 30. The wires 50, 51 and 52 are connected to the active elements in the antenna sections 32, 34 and 36, respectively, and provide the signals received by each of these antenna sections to processing circuitry. The wire 53 is connected to the ground of each of the antenna sections 32, 34 and 36 and, when connected to a vehicle, is also connected to the vehicular ground 54. Alternatively, two wires can be used to connect each antenna section 32, 34 and 36 to the processing circuitry, as described with respect to FIG. 1.

FIG. 3 illustrates the circuitry utilized to process the signals received by the antenna structure 30. Of course, the circuitry of FIG. 3 can also be utilized to process the signals received by the antenna structure 10. The signals received by the first antenna section 32 are transmitted over the wire 50 to a first RF processing circuit 70. The signals received by the second antenna section 34 are transmitted over the wire 51 to a duplexer 72 which then provides the received signals to a second RF processing circuit 74. The third antenna section 36 is preferably a Global Positioning Service (GPS) antenna. The signals received by the GPS antenna 36 are transmitted over the wire 52 to a GPS front end receiver and processor 76. The first RF processing circuit

70, the second RF processing circuit 74 and the GPS front end processor 76 each receive analog signals from the antenna structure 30 and convert the received signals into digital signals using any of the well known receiving methods. While digital systems are preferred, the antenna of the present invention is not limited to digital systems; rather, it is also useful to process analog signals in which case the processors can be analog processors.

The antenna sections 32, 34 and 36 can be adapted to receive a variety of communication signals -- primarily by adjusting the length of the antenna sections. In accordance with a preferred embodiment, however, the antenna sections 32 and 34 are adapted to receive communication signals in the same frequency range. Thus, the antenna sections 32 and 34 receive the same communication signals at different points in space. These communication signals are referred to as diversity signals. As previously described, the antenna section 36 is adapted to receive GPS signals.

The first RF processing circuit 70 and the second RF processing circuit 74 each send the diversity signals to a signal strength processor 78. The signal strength processor 78 compares various characteristics of the signals received from the first antenna section 32 to the characteristics of the signals received from the second antenna section 34. Based on the comparison, the signal strength processor 78 determines which signal should be processed and selects that signal for processing. The selected signal is then supplied to the baseband processor 80 for the appropriate baseband processing. The central controller 82 controls the operation of the signal strength processor 78 and the baseband processor 80.

The signal strength processor 78 can be any type of signal strength measuring device. For example, if analog signals are processed any of the well known circuits that measure the signal strength of analog

communication signals can be used to determine which diversity signal should be processed by the processor 80. If digital signals are being processed, a microprocessor can be used to determine the strength of the received signal. Additionally, any other measure of signal quality can also be used by the signal strength analyzer 78 to determine which signal to process.

Referring to FIG. 3, a transmitter 84 is provided to transmit communication signals. The transmitter 84 is connected to the second antenna section 34 through the duplexer 72 and the wire 51. Thus, a communication system using the antenna of the present invention can transmit through the antenna as well as receive diversity signals. While either the bottom antenna section 32 or the top antenna section 34 can be used to transmit, it is preferred to use the top antenna section 34.

It should also be noted that the antenna sections 32 and 34 can be used to receive communication signals in different frequency ranges. In this case, the signal strength processor 78 is presumably not needed since both signals will require processing.

Referring to FIG. 4, the antenna structure 30 is connected to a vehicle 90. The antenna structure is preferably mounted on top of the roof of the vehicle to provide optimal reception of signals. The antenna structure 30 can, however, also be mounted on the trunk as shown or anyplace else on or in the vehicle. The circuitry of FIG. 3 is preferably inside a radio terminal mounted inside the vehicle 90 for easy access by the driver of the vehicle 90.

It is understood that changes may be made in the above description without departing from the scope of the invention. It is accordingly intended that all matter contained in the above description and in the drawings be interpreted as illustrative rather than limiting.

30



I claim:

1. A linear diversity antenna for a vehicular radio terminal, comprising:
  - a first antenna section having a first end adapted to be supported  
5 on the vehicle and having a second end;
  - a second antenna section having a first end connected to the second end of the first antenna section such that the second antenna section is linearly oriented on top of the first antenna section; and
  - means for electrically isolating the first antenna section from the  
10 second antenna section;
  - wherein the first antenna section and the second antenna section receive signals in the same frequency range.
2. The linear diversity antenna of claim 1, further comprising:
  - 15 a first wire connected to a ground of the first antenna section;
  - a second wire connected to an output of the first antenna section
  - a third wire connected to a ground of the second antenna section;
  - and
  - a fourth wire connected to an output of the second antenna  
20 section.
3. The linear diversity antenna of claim 2, wherein the first to fourth wires extend from the first end of the first antenna section.
- 25 4. The linear diversity antenna of claim 1, further comprising:
  - a first wire connected to a ground of the first antenna section and to the ground of the second antenna section;
  - a second wire connected to an output of the first antenna section;
  - and
  - 30 a third wire connected to an output of the second antenna section.

5. The linear diversity antenna of claim 4, wherein the first to third wires extend from the first end of the first antenna section.
- 5 6. The linear diversity antenna of claim 1, wherein the first antenna section and the second antenna section are adapted to receive signals within the same frequency range.
- 10 7. The linear diversity antenna of claim 6, wherein one of the first and second antenna sections is used to transmit signals.
- 15 8. The linear diversity antenna of claim 6, wherein the second antenna section is used to transmit signals.
- 20 9. The linear diversity antenna of claim 1, wherein the first antenna section is adapted to receive signals within a first frequency range and the second antenna section is adapted to receive signals within a second frequency range.
- 25 10. The linear diversity antenna of claim 1, wherein the first antenna section is configured to receive communications within a first frequency range and the second antenna section is configured to receive GPS signals within a second frequency range.
- 30 11. The linear diversity antenna of claim 1, wherein the second antenna section has a second end, further comprising:  
a third antenna section having a first end connected to the second end of the second antenna section such that the third antenna section is vertically oriented on top of the second antenna section; and  
means for electrically isolating the second antenna section from the third antenna section.

12. The linear diversity antenna of claim 11, wherein the third antenna section receives signals within a second predetermined frequency range.

5 13. The linear diversity antenna of claim 11, wherein the third antenna section receives GPS signals.

14. The linear diversity antenna of claim 13, wherein one of the antenna sections is also adapted to transmit signals.

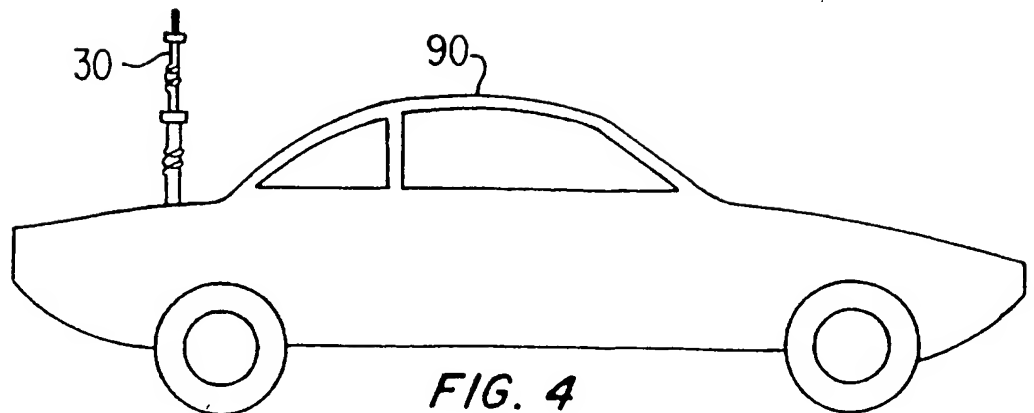
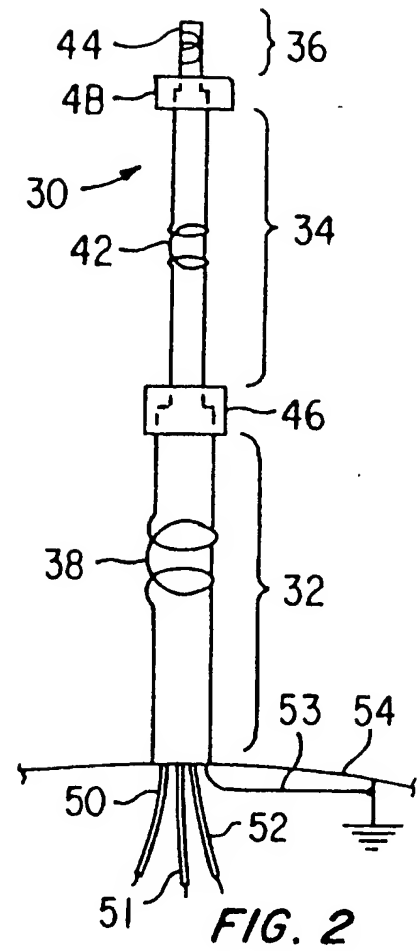
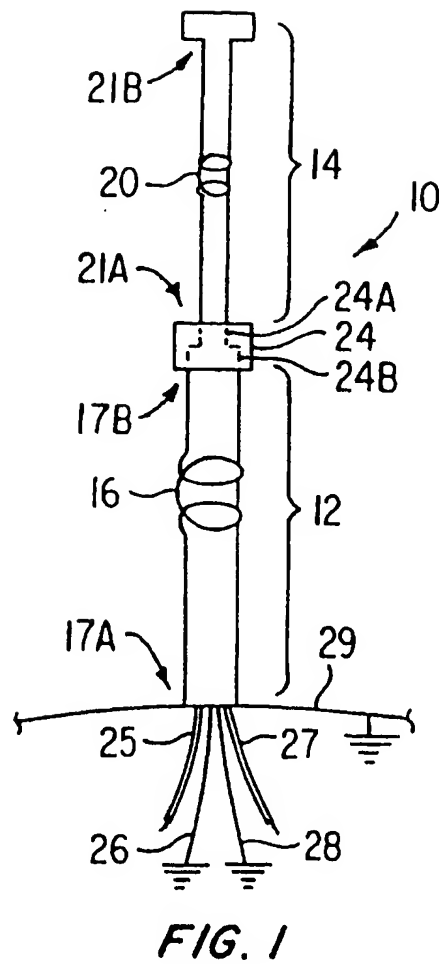
10 15. The linear diversity antenna of claim 13, wherein the second antenna section is also adapted to transmit signals.

16. Mobile communication apparatus, comprising:  
a vehicle;

15 an antenna having a first section and a second section, the first section having a first end supported on the vehicle with a vertical orientation and a second end, the second section having a first end connected to the second end of the first section such that the second section is vertically oriented on top of the first antenna section;

20 wherein the first section and the second section receive signals in the same frequency range.

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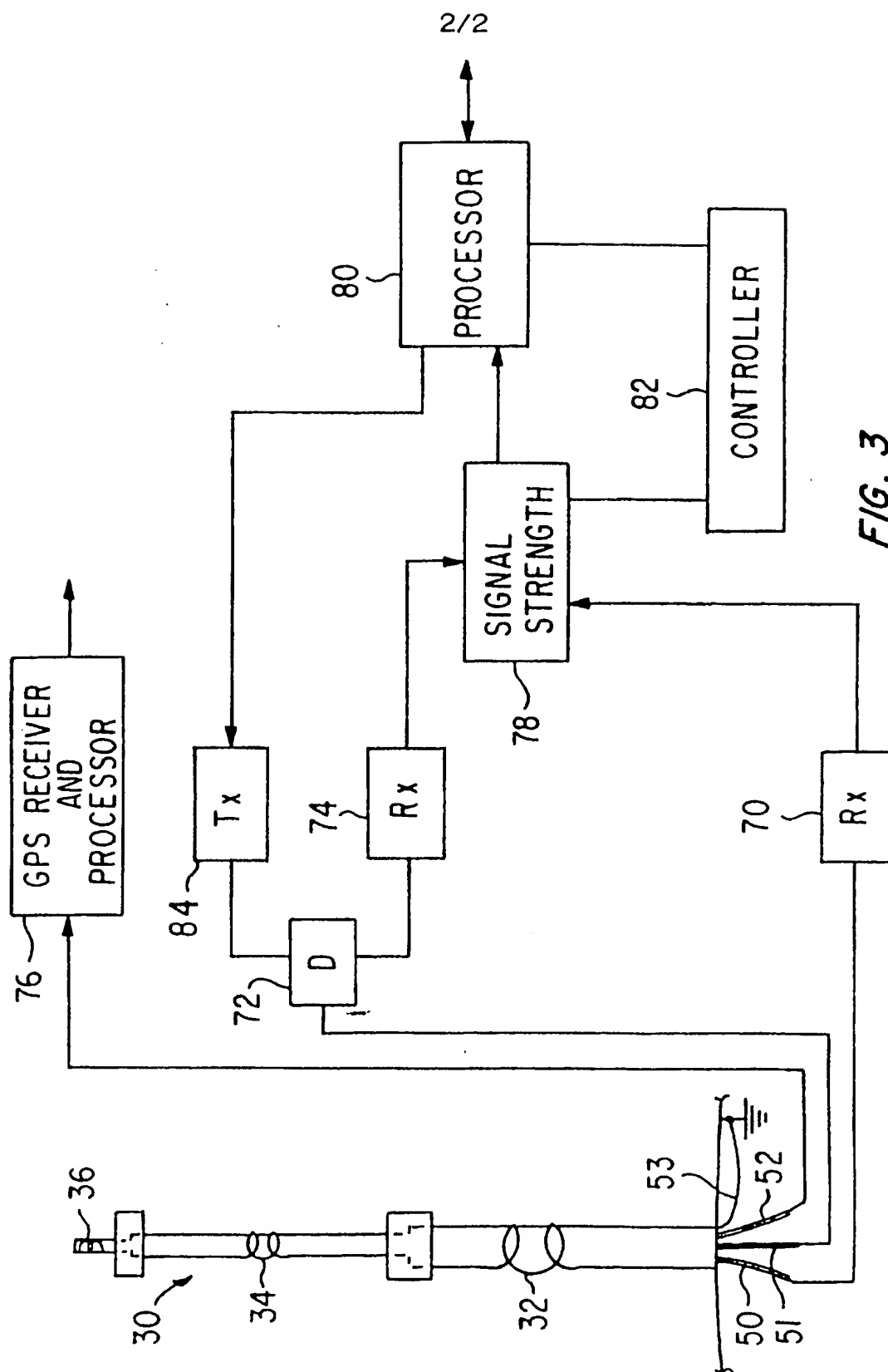


FIG. 3

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# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US96/17046

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : HO1Q 1/32, 9/04

US CL : 343/715, 790, 900, 893

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 343/715, 790, 900, 893, 725, 729, 791, 792; HO1Q1/32, 9/04.

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US, A 4,725,846 (HENDERSHOT) 16 FEBRUARY 1988. SEE FIGURE 1.	1-16
X	US, A 5,079,562 (YARSUNAS ET ALL.) 07 JANUARY 1992. SEE FIGURE 2.	1-16
X	US, A 5,345,247 (ALDAMA ET AL.) 06 SEPTEMBER 1994. SEE FIGURE 2.	1-16

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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